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(54) **APPARATUS AND METHOD FOR TRANSIENT AND UNINTERRUPTIBLE POWER**

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*F02D 29/06* (2006.01)

(52) **U.S. Cl.** .................... **290/40 C**; 290/38 R; 322/14; 322/10; 322/29; 322/4; 322/8; 322/28

(58) **Field of Classification Search** ............. 290/40 C, 290/38 R; 322/14, 10, 29, 4, 8, 28
See application file for complete search history.

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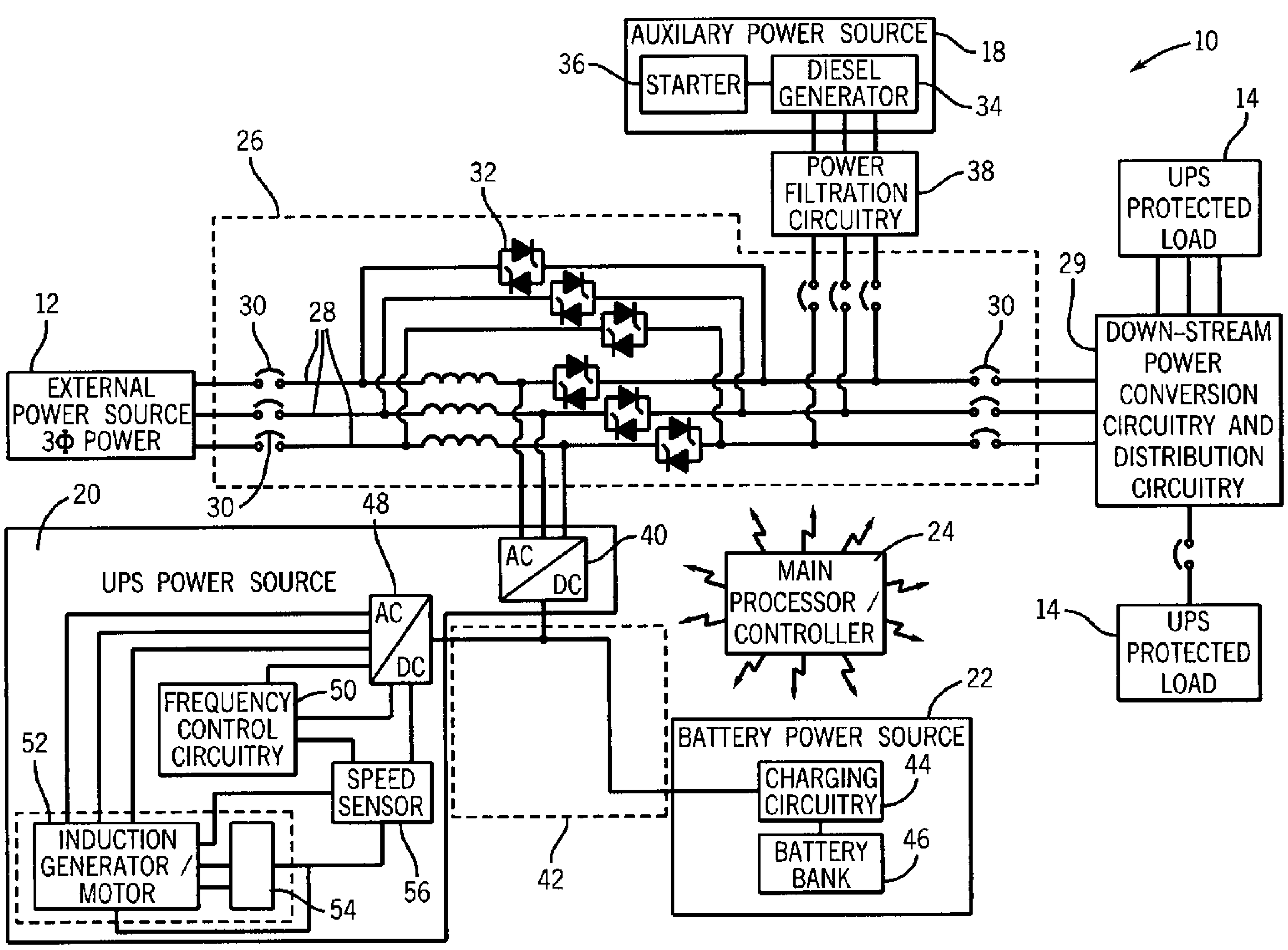
(57) **ABSTRACT**

In accordance with certain exemplary embodiments, the present technique provides methods and apparatus for providing transient and uninterrupted power to protected loads. As one example, the present invention provides an induction device that operates as an induction motor to energize a kinetic energy storage device, such as a flywheel, during conventional operating conditions. However, in the event of a loss of primary power, the induction device, which is fed ac power at variable frequencies, begins to operate as an induction generator. For example, by varying the frequency of the input ac power such that the synchronous speed of the motor is exceeded by the rotating flywheel, the induction device acts as an induction generator and provides a transient operating power to the downstream loads until an auxiliary power source, such as a diesel generator, is brought on line.

**9 Claims, 5 Drawing Sheets**



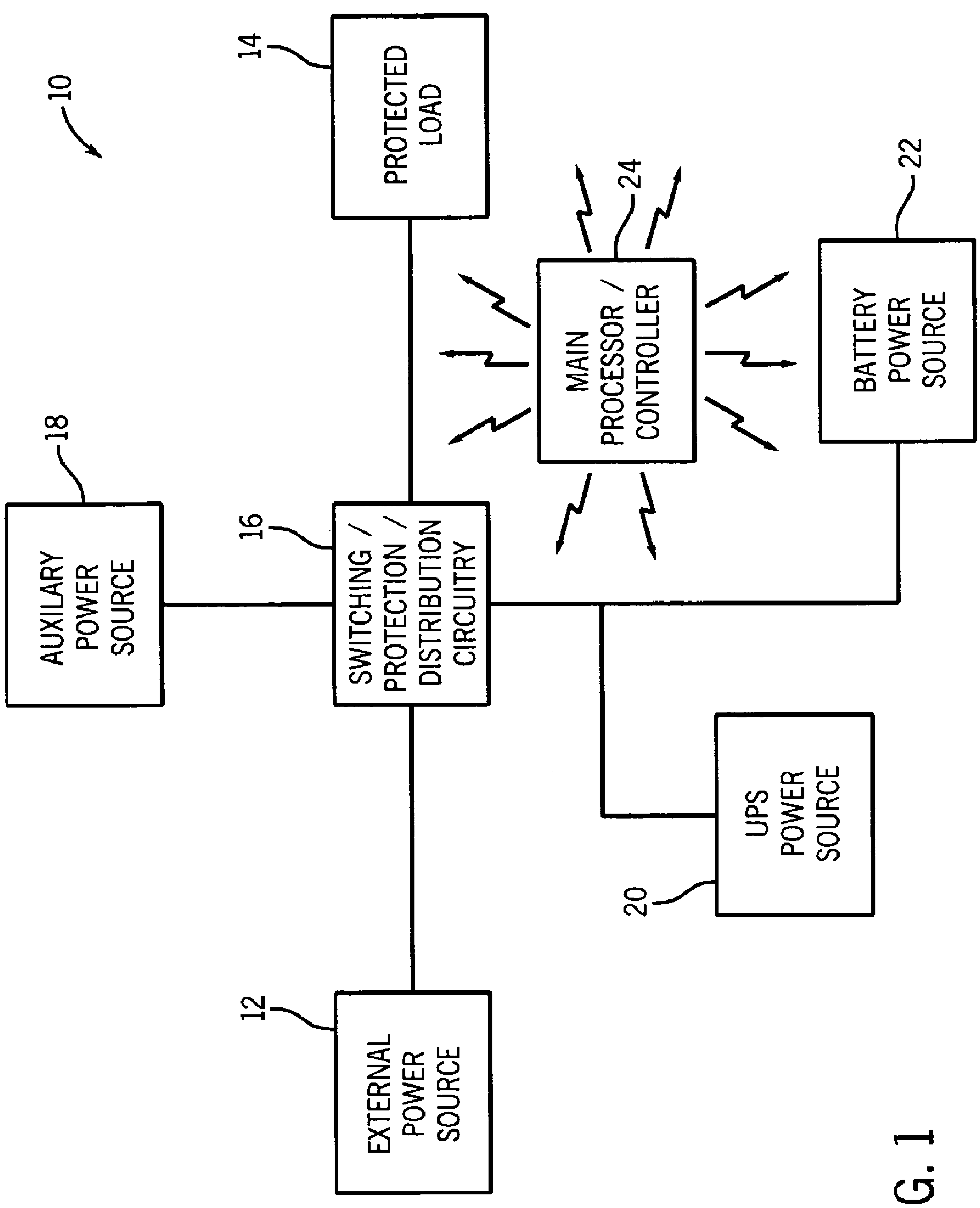

10
14
PROTECTED LOAD
24
MAIN PROCESSOR / CONTROLLER
22
BATTERY POWER SOURCE
18
AUXILARY POWER SOURCE
16
SWITCHING / PROTECTION / DISTRIBUTION CIRCUITRY
UPS POWER SOURCE
20
12
EXTERNAL POWER SOURCE

FIG. 1

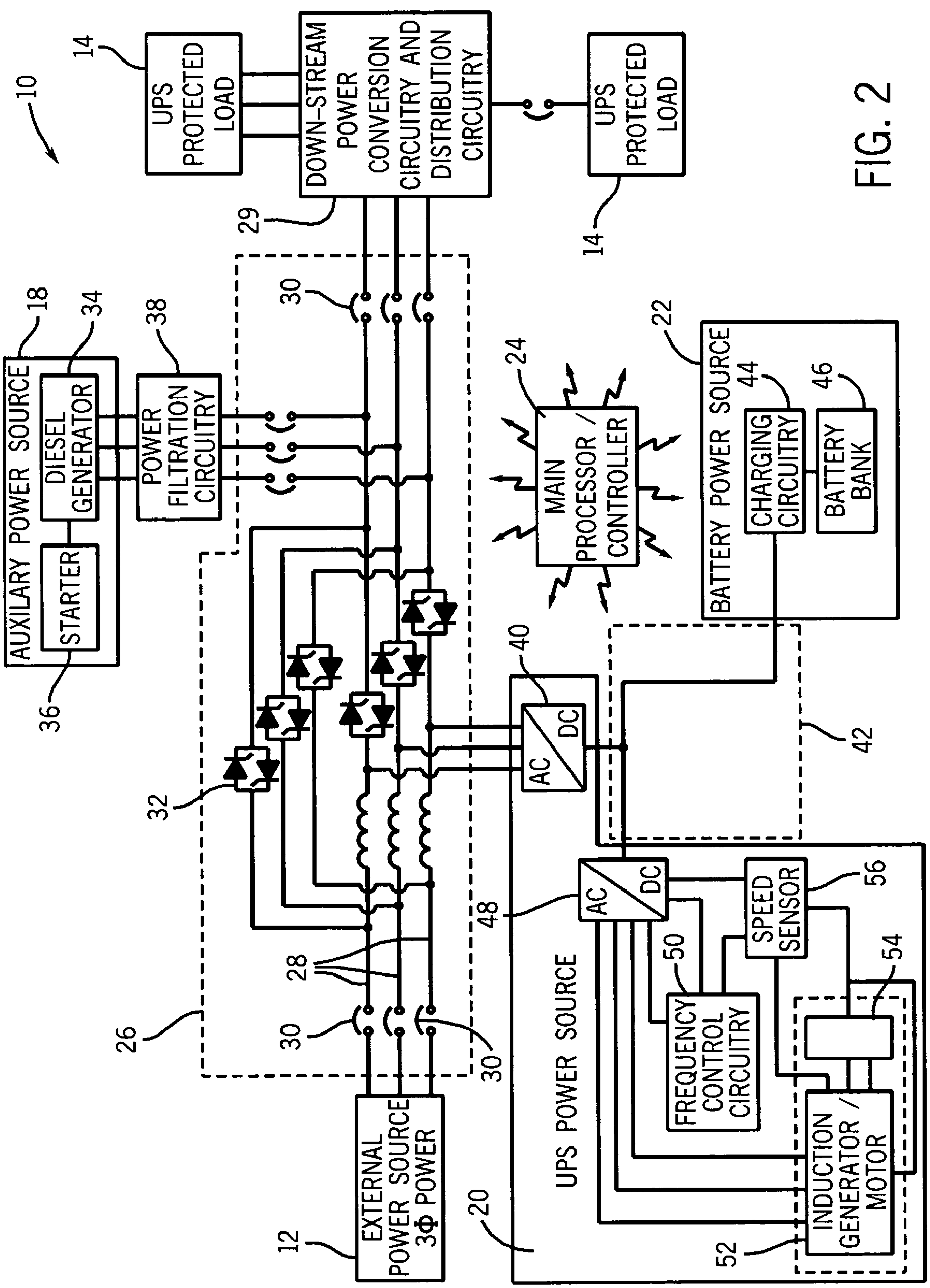

10
UPS PROTECTED LOAD
14
DOWN-STREAM POWER CONVERSION CIRCUITRY AND DISTRIBUTION CIRCUITRY
29
UPS PROTECTED LOAD
14
AUXILARY POWER SOURCE
18
DIESEL GENERATOR
34
STARTER
36
POWER FILTRATION CIRCUITRY
38
30
MAIN PROCESSOR / CONTROLLER
24
BATTERY POWER SOURCE
22
CHARGING CIRCUITRY
44
BATTERY BANK
46
40
AC
DC
42
32
48
DC
AC
SPEED SENSOR
56
50
54
28
26
30
30
FREQUENCY CONTROL CIRCUITRY
EXTERNAL POWER SOURCE 3Φ POWER
12
UPS POWER SOURCE
20
INDUCTION GENERATOR / MOTOR
52

FIG. 2

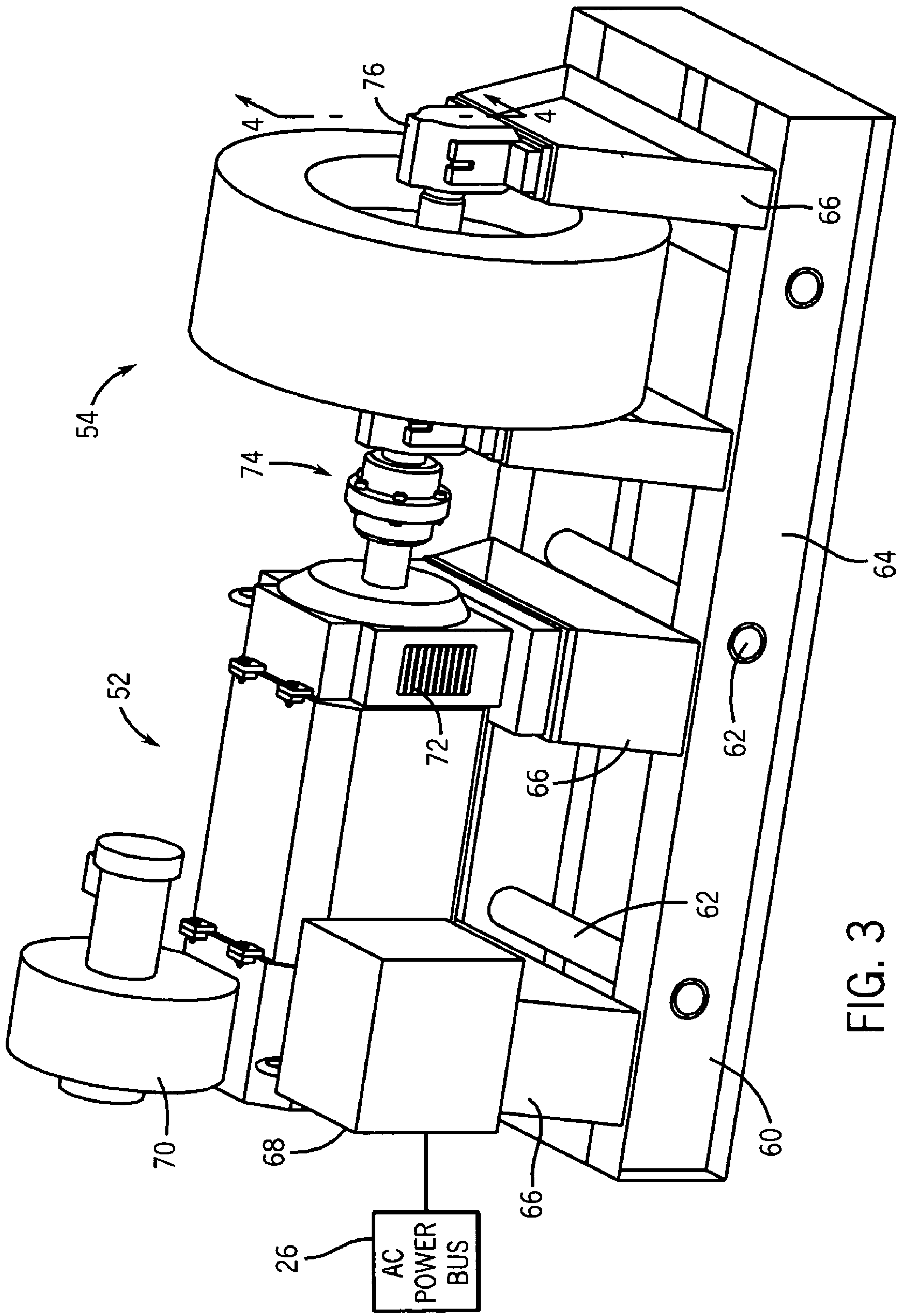



FIG. 3

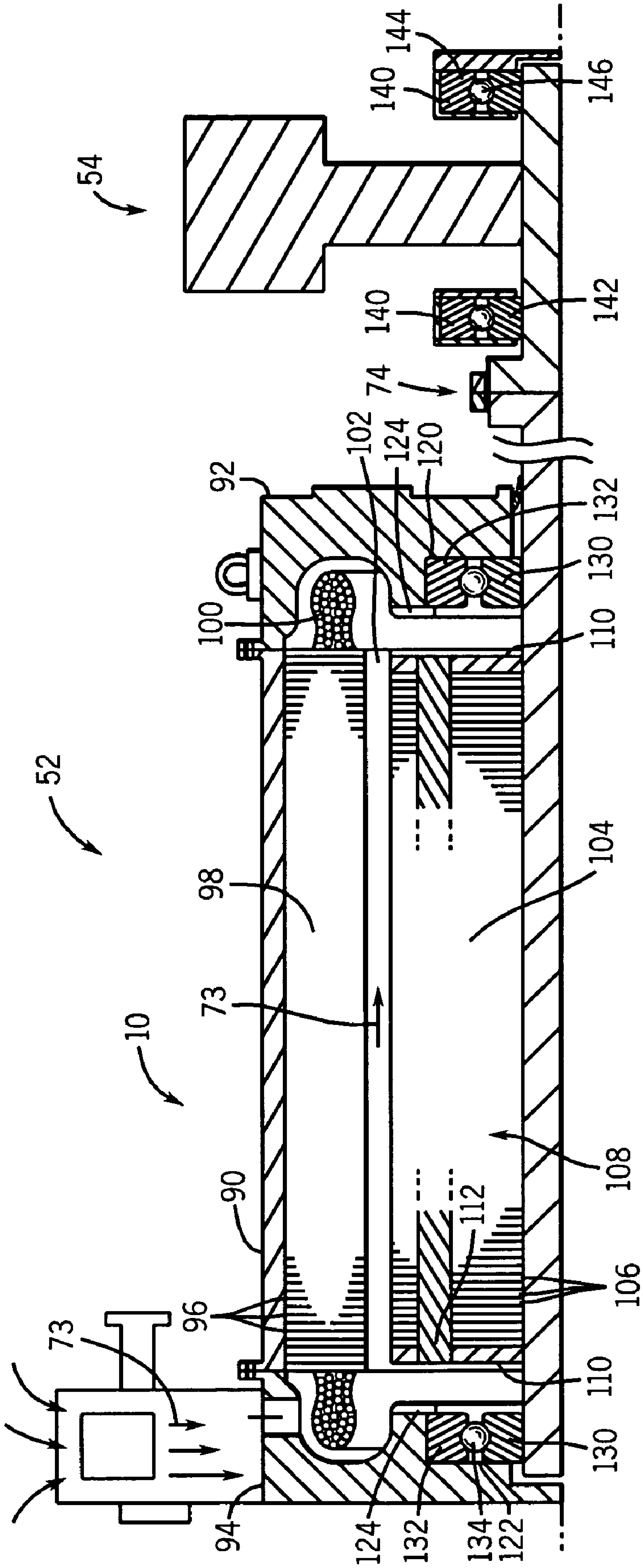

144
140
146
54
140
142
74
92
102
124
120
132
130
100
110
52
98
104
73
10
108
90
112
96
106
73
110
130
94
124
132
134
122

FIG. 4

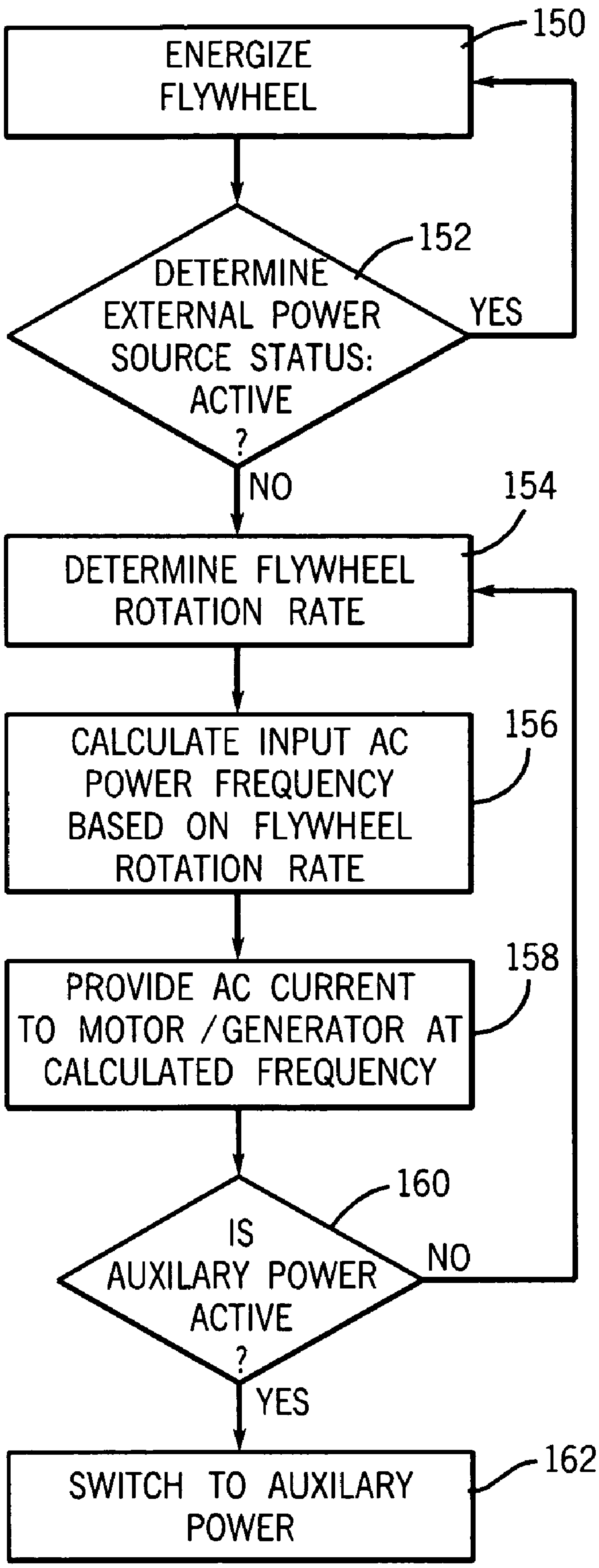

ENERGIZE FLYWHEEL
150
DETERMINE EXTERNAL POWER SOURCE STATUS: ACTIVE ?
152
YES
NO
DETERMINE FLYWHEEL ROTATION RATE
154
CALCULATE INPUT AC POWER FREQUENCY BASED ON FLYWHEEL ROTATION RATE
156
PROVIDE AC CURRENT TO MOTOR /GENERATOR AT CALCULATED FREQUENCY
158
IS AUXILARY POWER ACTIVE ?
160
NO
YES
SWITCH TO AUXILARY POWER
162

FIG. 5

# APPARATUS AND METHOD FOR TRANSIENT AND UNINTERRUPTIBLE POWER

## BACKGROUND

The present invention relates generally to a transient power supply and, more particularly, to method and apparatus for providing transient power by converting stored kinetic energy into electrical energy.

Typically, electrical devices receive operating power from an external power distribution grid that is coupled to a power generation facility, such as a power plant, for example. From time to time, this external power source can be interrupted, because of a malfunction in the generation facility and/or in the distribution grid, for instance. Accordingly, certain electrical devices are connected to an auxiliary power source, such as a diesel generator or a bank of batteries. Unfortunately, transitioning from the external power supply to the auxiliary power supply is generally not instantaneous and, as such, presents an interval of time during which the electrical devices are without power. For certain critical devices, such as computers or medical devices, even a momentary loss of power can lead to undesirable effects, such as a loss of critical data and/or malfunction of the device.

Accordingly, these critical devices traditionally have been coupled to a transient power supply, which is often referred to as an uninterruptible power supply (UPS) by those of ordinary skill of art in the industry. In summary, a transient power supply (i.e., UPS) provides operating power to the critical device from when the primary power is lost to the time at which the auxiliary power is brought on-line. Traditionally, battery banks have been employed to provide this transient power. As another example, certain flywheel devices have been employed to provide transient power.

Traditional flywheel devices include a rotating flywheel that is coupled to a generator and a motor. During normal operation, the motor operates off of main or primary power and energizes (i.e., kinetic energy of rotation) the flywheel. However, when power is lost, the flywheel remains in motion and operates a traditional generator, which generates power by rotating a permanent magnet or electromagnet within a stator core to induce current within stator windings disposed around the permanent magnet or electromagnet.

Unfortunately, traditional transient or UPS power sources are not without drawbacks. For example, battery banks that provide sufficient levels of power can be relatively expensive to purchase and maintain and, furthermore, often consume relatively large areas of floor space. In an industrial setting, for instance, cost and floor space are relevant concerns. As another example, traditional flywheel devices often require the maintenance of high rotation rates to generate sufficient and appropriate power. Accordingly, traditional flywheel devices often employ vacuum chambers to reduce the dissipation of kinetic energy from the flywheel due to air resistance, for example. Additionally, traditional flywheel devices employ a motor to energize the flywheel and a separate permanent magnet generator to convert the kinetic energy of the flywheel in to electrical power. By using two distinct devices (i.e., the generator and the motor), traditional systems bear a greater cost, and the use of the permanent magnet also increases the cost of the system. Furthermore, maintaining a vacuum condition for the flywheel increases the cost and likelihood of failure for the system.



Therefore, there exists a need for improved methods and apparatus for providing a transient power supply to certain electrical devices.

## BRIEF DESCRIPTION

In accordance with one exemplary embodiment, the present technique provides a power supplying apparatus. The exemplary power supplying apparatus includes a kinetic energy storage device, such as a rotatable flywheel. The exemplary power supplying apparatus also includes a rotor that is disposed in a stator and that is mechanically coupled to the kinetic energy storage device. The exemplary stator includes stator windings that receive power from a power source that is capable of providing alternating current (ac) power to the stator windings at variable frequencies to generate power by converting the kinetic energy of the flywheel into electrical energy.

During standard operation conditions, the exemplary power supplying apparatus functions as an induction motor, thereby energizing the kinetic energy storage device. However, if the external power supply to the apparatus is lost, then the exemplary apparatus functions as a transient power supply to coupled loads. By way of example, the energized flywheel (i.e., the kinetic energy device) continues to rotate even after a loss of external power and, as such, causes the rotor, which is mechanically coupled to the flywheel, to rotate as well. By providing ac power to the stator windings at an appropriately selected frequency, the exemplary power supplying device acts as an induction generator, for example. That is, the rotation of the rotor by the flywheel in conjunction with providing ac power at the appropriate frequency causes the rotor to rotate faster than the synchronous speed of the apparatus and, as such, generates ac power. This generated ac power is, by way of example, fed to a downstream load, thereby providing transient operating power to the downstream load during the loss of primary power, for instance.

In accordance with another exemplary embodiment, the present invention provides a method for providing transient power to a downstream load. The exemplary method includes the act of energizing a kinetic energy storage device, such as a rotatable flywheel. By way of example, the exemplary flywheel is coupled to a rotor of an electric machine, such as an induction device. In the exemplary method, providing ac power to the stator windings of the induction device induces current in the rotor and, in turn, causes the rotor to rotate. However, upon the loss of external operating power, for instance, the exemplary method actuates the rotor via the rotational energy stored in the flywheel. In cooperation with this actuation, the exemplary method includes that act of transmitting ac power to the stator winding at a selected frequency to generate power from the electric machine. That is, the ac power is transmitted at a frequency that causes the electric machine to operate as an induction generator and produce a transient operating power for the downstream load, for instance.

## DRAWINGS

These and other features, aspects, and advantages of the present invention will become better understood when the following detailed description is read with reference to the accompanying drawings in which like characters represent like parts throughout the drawings, wherein:

FIG. **1** is a schematic of a power distribution system for a protected load, in accordance with an embodiment of the present invention;

FIG. 2 is a schematic of a power distribution system for a protected load, in accordance with an embodiment of the present invention;

FIG. 3 is a perspective view of a transient power supply device, in accordance with an embodiment of the present invention;

FIG. 4 is a cross-sectional view of a the transient power supply device of FIG. 3 along line 4—4; and

FIG. 5 is a block diagram of an exemplary process for providing transient power, in accordance with an embodiment of the present invention.

## DETAILED DESCRIPTION

As discussed in detail below, the present invention provides methods and apparatus for providing power to loads. Although the following discussion focuses on providing transient power to a load, the present invention affords benefits to a number of power generation scenarios. Furthermore, the following discussion merely provides exemplary embodiments, and these examples are not intended to limit the scope of the appended claims. Additionally, as a preliminary matter, the definition of the term "or" for the purposes of the following discussion and the appended claims is intended to be an inclusive "or." That is, the term "or" is not intended to differentiate between two mutually exclusive alternatives. Rather, the term "or" when employed as a conjunction between two elements is defined as including one element by itself, the other element itself, and combinations and permutations of the elements. For example, a discussion or recitation employing the terminology "'A' or 'B'" includes: "A" by itself, "B" by itself, and any combination thereof, such as "AB" and/or "BA."

Turing to the figures, FIG. **1** is a diagrammatic representation of a power distribution system **10**. By way of example, the exemplary power system **10** is representative of a power distribution system in any number of facilities where continuous (i.e., uninterrupted) power distribution is a concern. For example, facilities such as hospitals, data centers and emergency facilities generally benefit from uninterrupted power. The exemplary power distribution system **10** includes an external power source **12**, such as a power generation plant, that provides operating power to a protected load **14** during conventional operating conditions. For example, the external power source **10** provides ac power to the protected load **14**, which may be a medical device, a data storage computer or a communications device, to name but a few examples. To manage the distribution of operating power to the protected load, the power distribution system **10** includes switching/protection/distribution circuitry **16**. The switching/protection/distribution circuitry **16** provides an electrical conduit for providing operating power to the protected load **14** from various power sources, which are discussed further below.

Under certain conditions, the external power source **12** can be lost. For example, in the event of a power outage or a transmission line failure, external power from the external power source **12** is no longer available to the protected load **14**. Indeed, due to certain events, such as weather events, external power may be lost for relatively long durations of time. To mitigate the effects of a loss of external power, the exemplary power distribution system **10** includes an auxiliary power source **18**, such as a diesel generator. Advantageously, the exemplary auxiliary power source **18** is capable of providing operating power to the protected load for extended periods of time. However, delays in activating the auxiliary power source **18** from the time of loss of external power leaves the protected load **14** without operating power during this interval. For example, in the case of a diesel generator, a period of seconds may pass between the time external power is lost and the time the diesel generator is capable of providing operating power (i.e., brought on-line). This lag time can cause the protected load to deactivate, leading to a loss of data, for instance.

To provide operating power during this transition between power sources, the exemplary power distribution system includes an uninterruptible power supply (UPS) power source **20**. As discussed further below, the UPS **20** provides transient operating power to the protected load from the time when external power is lost to the time the auxiliary power source **18** is brought on-line. Accordingly, the protected load **14** in the exemplary power distribution system **10** never realizes a loss of operating power. Additionally, the protected load **14**, in the exemplary power distribution system **10**, receives transient power from a battery power source **22**. However, it is worth noting that the battery power source **22** is included as an optional component in the exemplary embodiment, and other embodiments of the present technique can be configured to receive all transient power from the UPS power source **20** and, as such, do not include a battery power source **22**.

To manage and/or monitor the various power sources as well as the protected load, the exemplary power distribution system **10** includes a main processor/controller **24** that is in communication with the various components of the power distribution system **10**. In the exemplary power distribution system **10**, the main processor/controller includes logic circuitry configured to automate control and monitoring the power distribution system **10**. Advantageously, the exemplary main processor/controller **24** is configured to communicate with remote locations via a network, for example.

FIG. **2** illustrates in further detail an exemplary power distribution system (PDS) **10**. In the exemplary PDS **10**, the external power source **14** provides three-phase **480** Vac power to the system, and this power is distributed throughout the system over an ac bus **26**. The exemplary ac bus **26** includes three conductive pathways **28**, each of which carries one phase of the three-phase power. In the exemplary embodiment, the ac bus **26** electrically communicates with downstream power conversion and distribution circuitry **29** that provides power to various UPS protected loads. For example, the exemplary downstream power conversion and distribution circuitry **29** provides three-phase ac power to one UPS protected load **14**, while providing single-phase ac power to another UPS protected load **14**. As will be appreciated by those of ordinary skill in the art in view of the following discussion, the exemplary PDS **10** may include any number of protected loads **14** operating at any number of power levels.

The exemplary ac bus **26** includes switching/distribution/protection (SDP) circuitry **16** to manage the transmission of operating power to the protected loads **14**. For example, the ac bus **26** includes fuses **30** that mitigate the likelihood of improper power levels affecting the various components of the PDS **10**. However, these fuses **30** are merely one example of protection circuitry and devices, which include circuit breakers and interruption devices, to name but a few devices. The exemplary ac bus **26** also includes static transfer switches **32**, which are under the direction of the main processor/controller **24**, for example. The exemplary static transfer switches **32** control from which power source (e.g., the external power source **12**, the UPS power source **20** and/or the auxiliary power source **18**) the protected loads **14** receive operating power. Of course, the static transfer switches **32** are merely one example of a switching circuit or device, and those of ordinary skill in the art may envisage any number of devices in view of the present discussion.

As discussed above, to mitigate the effects of a loss of the external power source **12**, the PDS **10** includes an auxiliary power source **18**. In exemplary embodiment, the auxiliary power source **18** includes a diesel generator **34** that is coupled to a motor starter **36**. Thus, in the event external power is lost, the main processor/controller **24** instructs the motor starter **36** to activate the diesel generator, for instance. In the exemplary PDS **10**, power filtration circuitry **38** located electrically between the diesel generator **34** and the ac bus **26** conditions the power generated by the diesel generator **34** to an appropriate level for the ac bus **26**. Unfortunately, the exemplary diesel generator **34** does not instantaneously reach an operational state, i.e., a state at which the generator **34** is capable of providing operating power.

Accordingly, the exemplary PDS **10**, as discussed above, includes the UPS power source **20**. The exemplary UPS power source **20**, via the ac bus **26**, provides transient operating power to the UPS protected loads **14** and, as such, bridges the interval between the loss of external power and the activation of the diesel generator **34**.

During conventional operations (i.e., operating under external power), the UPS power source **20** receives external operating power via the ac bus **26**. In the exemplary UPS power source **20**, first power conversion circuitry **40**, which is bi-directional, receives ac power from the ac bus **26** and converts this ac power into dc power. By way of example, the exemplary first power conversion circuitry **40** rectifies 480 Vac power into 800 V dc power. As will be appreciated by those of ordinary skill in the art, the exemplary first power conversion circuitry **40** includes an assembly of inverters and rectifiers that appropriately condition the input power to a desired output level. Indeed, any number of input power levels can be converted into any number of output levels, in accordance with the appropriate design parameters of a given system.

In the exemplary embodiment, this dc power is then distributed to various components of the PDS **10** over a dc bus **42**. As one example, the dc bus **42** is in electrical communication with the battery power source **22**. Accordingly, during conventional operations, the dc bus **42** feeds dc power to exemplary charging circuitry **44** that, in turn, charges a battery bank **46**. By way of example, the exemplary battery power source **22** includes rechargeable nickel-cadmium batteries; of course, other types of batteries may be envisaged.

The dc bus **42** also feeds into and communicates with second power conversion circuitry **48** of the UPS power source **20**. Like the first power conversion circuitry **40**, the exemplary second power conversion circuitry **48** includes appropriately arranged rectifiers and inverters and is bi-directional. This exemplary second power conversion circuitry **48**, during conventional operating conditions, is configured to receive dc power from the dc bus **42** and output three-phase ac power at a variable frequency. To select the frequency of the output ac power, the exemplary UPS power source **20** includes frequency control circuitry **50**, which is in communication with the main processor/controller **24**.

The ac power output from the second power conversion circuitry **48** provides operating power to an induction device **52** that operates as an induction motor during conventional operating conditions. That is, the exemplary second power conversion circuitry **48** provides power to the stator windings of the exemplary induction device **52** to cause rotation of the rotor of the induction device. (See FIG. **4**.)

In the exemplary UPS power source **20**, the induction device **52** is mechanically coupled to a kinetic energy storage device, such as the illustrated flywheel **54**. Accordingly, during conventional operations, induction device **52** acts as an induction motor and energizes the flywheel **54**. That is, the rotation of the rotor (See FIG. **4**) of the induction device causes the flywheel **54** to rotate as well. To monitor the operation of the induction device **52** or the flywheel **52**, the exemplary UPS power source includes sensing devices, such as the illustrated speed sensor **56**. The exemplary speed sensor **56** is configured to determine a rotational rate (i.e., rotations per minute) of the rotor or the flywheel, for example. Advantageously, the exemplary speed sensor **56** is in communication with the main processor/controller **24**. Advantageously, the induction device when operating as an induction motor may be harnessed to operate a given piece of machinery, such as a pump element, for example.

FIG. **3** illustrates an exemplary induction device **52** and flywheel assembly **54**. The exemplary assembly includes a base **60** onto which the induction device **52** and flywheel **54** are mounted. To increase the structural integrity of the assembly, the base **60** includes a series of struts **62** disposed between legs **64** of the base **60**. To support the induction device **52** and the flywheel **54**, the exemplary assembly includes trapezoidal shaped mounting structures **66** that secure these components to the base **60**.

The exemplary induction device **52**, as discussed further below, is an induction generator/motor. To facilitate electrical communications to and from the exemplary induction device **52**, a conduit box **68** is included. By way of example, the conduit box **68** includes connections to couple the exemplary induction device **52** to the ac power bus **26** and, as such, facilitates the receipt of operating power and the transmission of generated power, for instance. Advantageously, the exemplary induction device **52** includes a cooling system **70** that draws air into the induction device **52** and expels the air from a vent **72** located at the opposite end of the device **52**. Indeed, in the exemplary induction device **52**, the cooling system **70** draws in air and generates airflow through the device **52**, as represented by directional arrows **73**. (See FIG. **4**.)

The exemplary induction device **52** is mechanically coupled to the flywheel **52** via a shaft assembly **74**. Although the present embodiment illustrates a single flywheel, embodiments with two or more flywheels are envisaged. Indeed, the induction device **52** may be coupled to a pair of flywheels that are disposed on opposite ends of the induction device **52**. Furthermore, it is envisaged that the rotor, via the shaft assembly **74**, can be coupled to a gearbox, for example, that distributes the torque of the rotor to any number of flywheels **54**. Advantageously, the use of multiple flywheels facilities the use of smaller flywheels in maintaining a desired amount of stored kinetic energy within the system.

The shaft assembly **74** mechanically correlates the rotation of the rotor (see FIG. **4**) of the induction device **52** with the rotation of the flywheel **54**. That is to say, the rotational rate (e.g., rpm) of the rotor corresponds with the rotational rate of the flywheel **54**, for example. However, the induction device **52** and the flywheel may be mechanically coupled via other mechanical assemblies, such as gears and speed reducers, that impact the rotations rates of the rotor and the flywheel with respect to one another. Additionally, as discussed further below, the exemplary flywheel **54** includes bearing assemblies **76** that are coupled the mounting structures **66** and that facilitate rotational movement of the flywheel **54**.

FIG. **4** provides a partial cross-section view of the induction device **52** and flywheel **54** along line **4**—**4**. To simplify the discussion, only the top portions of the induction device **52** and flywheel **54** are shown, because the structures of these components are essentially mirrored along their respective centerlines.

Beginning with the exemplary induction device **52**, it includes a frame **90** and drive-end and opposite drive-end endcaps **92** and **94** respectively. These endcaps **92** and **94**, in cooperation with the frame **90**, provide an enclosure or device housing for the exemplary induction device **52**. Within the enclosure or device housing resides a plurality of stator laminations **96** juxtaposed and aligned with respect to one another to form a stator core **98**. The stator laminations **96** each include features that cooperate with one another to form slots that extend the length of the stator core **98** and that are configured to receive one or more turns of a coil winding **100**, illustrated as coil ends in FIG. **4**. These coil windings **100** are in electrical communication with the ac bus **26** (see FIG. **3**). Accordingly, the coil windings **100** receive operating power from the ac bus **26** and provided generated power to the ac bus **26**, as discussed further below. Each stator lamination **96** also has a central aperture. When aligned with respect to one another, the central apertures of the stator laminations **96** cooperate to form a contiguous rotor passageway **102** that extends through the stator core **98**.

In the exemplary induction device **52**, a rotor **104** resides within this rotor passageway **102**. Similar to the stator core **98**, the rotor **104** has a plurality of rotor laminations **106** aligned and adjacently placed with respect to one another. Thus, the rotor laminations **106** cooperate to form a contiguous rotor **108**. The exemplary rotor **104** also includes rotor end rings **110**, disposed on each end of the rotor **104**, that cooperate to secure the rotor laminations **106** with respect to one another. The exemplary rotor **104** also includes rotor conductor bars **112** that extend the length of the rotor **104**. In the exemplary induction device **52**, the end rings **110** electrically couple the conductor bars **112** to one another. Accordingly, the conductor bars **112** and the end rings **110** comprise nonmagnetic, yet electrically conductive materials and form one or more closed electrical pathways. As discussed below, routing alternating current through the stator windings **100** induces current in the rotor **104**, specifically in the conductor bars **112**, and causes the rotor **104** to rotate. By harnessing the rotation of the rotor **104** via the shaft assembly **74**, the flywheel **54** rotates as well. Conversely, rotating the rotor **104** at a rate above the synchronous speed of the induction device, which is a function of the input ac power fed to the stator windings **100**, causes the induction device **52** to generate power, as discussed further below. Indeed, those of ordinary skill in the art will appreciate that the synchronous speed ($N_s$; as measure in rotations per minute) of an induction device is generally defined by the follow equation:

$$N_s = \frac{120(F)}{P},$$

in which F represents the frequency of the input ac power in Hertz and P represents the even integer number of poles of the induction device.

To support the rotor **104**, the exemplary induction device **52** includes drive-end and opposite drive-end bearing sets **120** and **122** that are secured to the shaft assembly **74** and that facilitate rotation of the rotor **104** within the rotor passageway **102**. By way of example, the exemplary bearing sets **120** and **122** have a ball bearing construction; however, the bearing sets may have a sleeve bearing construction, among other types of bearing constructions. Advantageously, the endcaps **92** and **94** include features, such as the illustrated inner bearing caps **124**, that releasably secure the bearing sets **120** and **122** within their respective endcaps **92** and **94**. The exemplary bearing sets **120** and **122** transfer the radial and thrust loads produced by the rotor **104** to the device housing. Each exemplary bearing set **120** and **122** includes an inner race **130** disposed circumferentially about the shaft assembly **74**. The fit between the inner races **130** and the shaft assembly **74** causes the inner races **130** to rotate in conjunction with the shaft assembly **74**. Each exemplary bearing set **120** and **122** also includes an outer race **132** and rolling elements **134** disposed between the inner race **130** and the outer race **132**. The rolling elements **134** facilitate rotation of the inner races **130**, while the outer races **132** remain stationary with respect to the endcaps **92** and **94**. Thus, the bearing sets **120** and **122** facilitate rotation of the shaft assembly **74** and the rotor **104** while providing a support structure for the rotor **104** within the device housing, i.e., the frame **90** and the endcaps **92** and **94**. To improve the performance of the bearing sets **120** and **122**, a lubricant coats the rolling elements **134** and races **130** and **132**, providing a separating film between to bearing components, thereby mitigating the likelihood of seizing, galling, welding, excessive friction, and/or excessive wear, to name a few adverse effects.

The shaft assembly **74**, in the exemplary embodiment, mechanically couples the rotor **104** to the flywheel **54**. That is to say, the rotation of the rotor **104** causes the flywheel **54** to rotate, and, conversely, rotation of the flywheel **54** causes the rotor **104** to rotate. The exemplary flywheel **54** includes bearing sets **140**, which each includes an inner race **142**, an outer race **144**, and a rolling elements **146** disposed therebetween. Similar to the bearing sets **120** and **122**, the inner races **142** rotate in conjunction with the shaft assembly **74**, while the outer races **144** remain stationary. Advantageously, the components of the exemplary bearing sets **140** are coated with a lubricant, to mitigate the likelihood of seizing, galling, welding, excessive friction, and/or excessive wear, to name a few adverse effects.

Focusing on the exemplary flywheel **54**, it is designed to store and transfer kinetic energy. Accordingly, the exemplary flywheel **54** is formed of composite materials suited to maintain the inertial rotation of the flywheel. Of course, those of ordinary skill in the art in light of the present discussion will appreciate that the flywheel **54** may be formed of any number of suitable structural materials. Furthermore, such skilled artisans will also appreciate that the I-shaped cross-section design of the exemplary flywheel is merely but one example of a flywheel design.

With the foregoing figures (i.e., FIGS. **1**–**4**) in mind, FIG. **5** illustrates an exemplary process for operation of the exemplary UPS power source **20** within the exemplary power distribution system **10**. As discussed above, during conventional operating conditions, the ac power bus **26** provides ac power from the external power source **12** to the stator windings **100** of the induction device **52**. More specifically, in the exemplary induction device **52**, the ac bus **26** provides ac power to the first power conversion circuitry **40**, which coverts the inputted ac power to a dc power. Via the dc bus **42**, this dc power is provided to second power conversion circuitry **48**, which converts the inputted dc power into an ac power at a desired frequency. This ac power is then provided to the stator windings **100**, inducing current in the conductor bars **112** and causing the rotor **108** to rotate. Because the shaft assembly **74** mechanically couples the rotor **104** to the flywheel **54**, the flywheel **54** rotates at the rotational rate (i.e., rpm) of the rotor **104**. Thus, the electrical energy from the external power source **12** is converted into kinetic energy and stored in the flywheel **54**. That is to say, the flywheel **54** is energized, as represented by Block **150**. If the external power source is providing power to the PDS **10**, the then UPS power source **20** remains in the energizing state, as represented by Block **152**.

However, if a loss of external power is detected, by the main processor/controller **24**, for instance, then the UPS power source **20** switches to a fault status state, as represented by Block **152**. In the event of a fault status state (i.e., a loss of external power), the stator windings **100** no longer receive ac power from the external power source via ac power bus **26**. However, the kinetic energy stored in the rotating flywheel **54** continues to rotate the rotor **104**, because the rotor **104** is coupled to the flywheel. As discussed above, the exemplary speed sensor **56** monitors and detects the rotational rate of the flywheel **54** in rotations per minute (rpm), for instance, as represented by block **154**. (As will be appreciated by those of ordinary skill in the art in view of the present discussion, the exemplary flywheel **54** and the exemplary rotor **104** rotate at the same rate, which is measured in rpm.)

Immediately upon the loss of external power, the frequency control circuitry **50**, in response to inputs from the speed sensor **56** and/or the main processor/controller **24**, directs the exemplary second power conversion circuitry **48** to adjust the output frequency thereof, to generate power from the induction device **52**. That is, the frequency controller **50** directs the second power conversion circuitry **48** to output ac power at a frequency such that the rotor **104** is rotating faster than the synchronous speed of the induction device **52**. Again, the synchronous speed of the induction device **52** is partially defined by the frequency of the ac power provided to the stator windings **100**. Thus, by selecting a frequency that defines a synchronous speed for the induction device **52** that is less than the rotation rate of the flywheel, the induction device **52** acts as an induction generator and, as such, provides a generated ac power to the second power conversion circuitry **48**. As the flywheel **54** loses kinetic energy and slows down, the speed sensor **56** monitors this reduction in speed and calculates an ac frequency that maintains operation of the induction device **52** as an induction generator. Blocks **156** and **158** represent these steps of the exemplary process.

In the exemplary process, the second power conversion circuitry **48** receives the generated ac power and converts this power to dc power for transmission over the dc bus **42**. The first power conversion circuitry **40** then receives the dc power from the dc bus **42** and converts the input dc power into an ac power appropriate for the ac bus **26**, which distributes the power to downstream locations, such as the UPS protected loads **14**.

The exemplary process also includes activating the auxiliary power source **18**, such as the exemplary diesel generator **34**. By way of example, the exemplary diesel generator **24** is activated via a motor starter, which takes a few seconds to bring the diesel generator online, for instance. Accordingly, the UPS power source **20** provides a bridge between the time at which external power is lost and the time that the auxiliary power is brought on-line. Once the auxiliary power source is brought on-line, the PDS **10** obtains its operating power from the auxiliary power source, as represented by Blocks **160** and **162**.

While only certain features of the invention have been illustrated and described herein, many modifications and changes will occur to those skilled in the art. It is, therefore, to be understood that the appended claims are intended to cover all such modifications and changes as fall within the true spirit of the invention.

The invention claimed is:

**1**. A method for providing transient power to a load, comprising:

energizing a kinetic energy storage device that is mechanically coupled to a rotor of an electric machine;

actuating the rotor via the kinetic energy storage device;

providing alternating current (ac) power at a selected frequency to stator windings disposed in a stator of the electric machine to generate power from the electric machine; and

conditioning the generated power to match the frequency and voltage of an external alternating current power configured to provide operating power to a load during operation.

**2**. The method as recited in claim **1**, comprising sensing a parameter of the kinetic energy storage device or the rotor and basing the selected frequency on the parameter.

**3**. The method as recited in claim **2**, comprising determining the rotational rate of the rotor.

**4**. The method as recited in claim **2**, comprising rectifying generated power from ac power to direct current (dc) power.

**5**. The method as recited in claim **4**, comprising inverting dc power to ac power.

**6**. A method for providing transient power to a load, comprising:

energizing a rotatable flywheel that is coupled to a rotor of an electric machine;

monitoring an external power source that provides operating power to the load;

providing first alternating current (ac) power at a variable frequency to stator windings disposed in a stator of the electric machine to generate second ac power via the electric machine upon loss of the external power; and

conditioning the second ac power to provide transient operating power to the load.

**7**. The method as recited in claim **6**, comprising sensing an operating parameter of the rotor or the rotatable flywheel and basing the variable frequency on the parameter.

**8**. The method as recited in claim **6**, comprising energizing the rotatable flywheel by inducing a current in electrical conductors extending through the rotor.

**9**. A system for providing a transient power supply, comprising:

means for energizing a kinetic energy storage device that is mechanically coupled to a rotor of an electric machine;

means for actuating the rotor via the kinetic energy storage device;

means for determining an operating parameter of the kinetic energy device or the rotor;

means for providing alternating current (ac) power at a selected frequency to stator windings disposed in a stator of the electric machine to generate power, wherein the selected frequency is based on the operating parameter; and

means for conditioning the generated power to match the frequency and voltage of an external alternating current power configured to provide operating power to a load during operation.

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